Magnetic exchange coupling between ferromagnets and antiferromagnets studied as function of domain size

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INTRODUCTION

Knowledge of the magnetic interface structure at ferromagnet-antiferromagnet interfaces is essential for a better understanding of the effect of exchange bias in magnetic multilayers. Exchange bias is observed as a unidirectional anisotropy of the coupled ferromagnetic layer, forcing its magnetization in a preferred direction by exchange coupling to the antiferromagnet. This effect is used in magnetic devices, such as giant-magneto-resistance (GMR) hard-disk read heads and magnetic random access memory (MRAM). We have investigated exchange coupling at $LaFeO_3$ interfaces using the Photoelectron Emission Microscope PEEM2 located at beamline 7.3.1.1 of the Advanced Light Source. Investigations of the antiferromagnetic domain structure of $LaFeO_3$ thin films and magnetic exchange coupling between $LaFeO_3$ and ferromagnetic Co have been reported earlier [1,2]. Here we will discuss the effect of the domain size and antiferromagnetic film thickness on the domain structure and exchange coupling.

RESULTS

Exchange coupling at the interface between $LaFeO_3$ and Co leads to a correlation of the domain structures of the two layers and a results in a parallel coupling between of the in-plane components of the magnetic vectors. Furthermore magnetic bias has been observed locally in single domains. This has been achieved by acquiring PEEM images in remanence as function of the applied field. Calculated hysteresis curves show a clear local exchange bias. We have now developed a software utility which analysis local remanent hysteresis curves pixel-by-pixel and generates maps of the local bias and the local coercivity. This program efficiently analyzes stacks of magnetic PEEM images, consisting of 1024x1024 pixel, which were acquired as function of

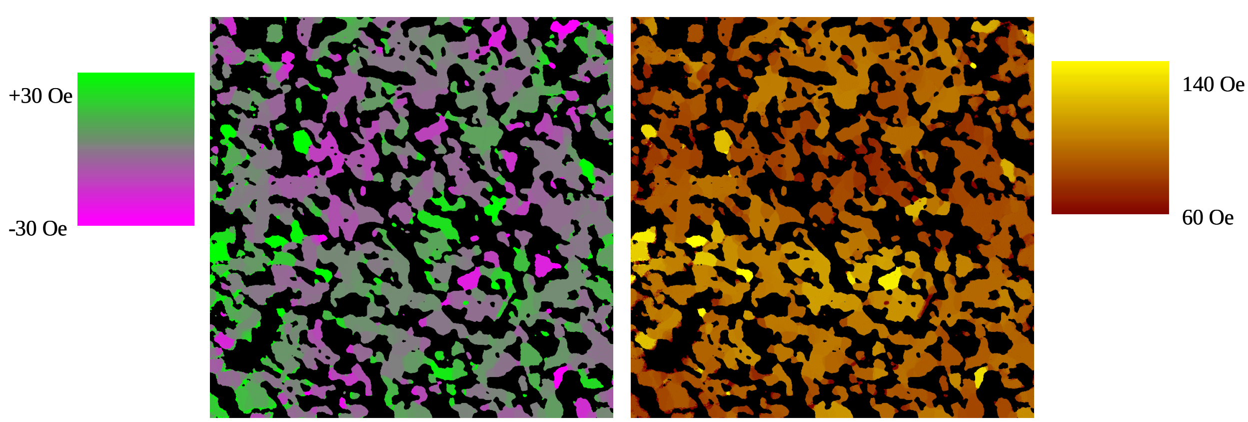

Fig. 1: Maps of bias (left) and coercivity(right) of $Co/LaFeO_3$

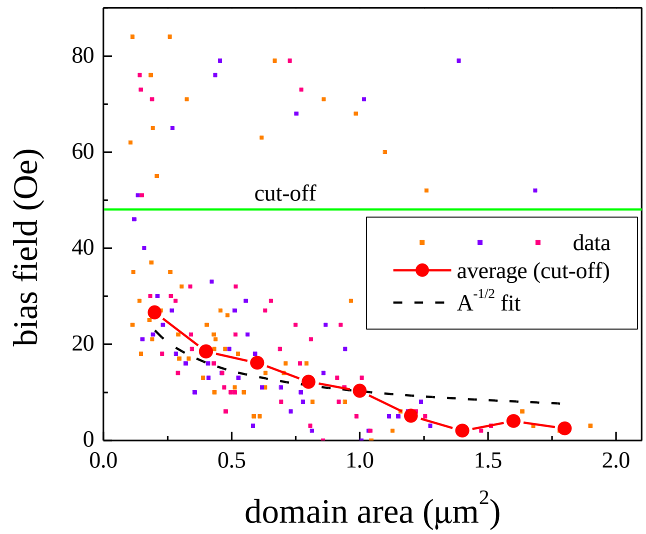

Fig. 2: Distribution of exchange bias as function of domain area

applied magnetic field. The result of such an analysis is shown in Fig, 1. A coercivity map is shown to the left, and a bias field map is shown to the right. Note that the sample was not field-annealed or field-grown. The sign of the observed bias is therefore random. Histograms of the measured local bias field and coercivity show bias fields of up to -30 to +30 Oe and typical coercivities of around 100 Oe. The distribution of the bias field can be fitted assuming a gaussian distribution.

We have also analyzed the size of the local bias field as function of domain size using a second software utility. The result of this analysis for three independent data sets, which were acquired in the same area, is displayed in Fig. 2. The bias field clearly decreases with increasing domain size. Large circles show the average bias in a particular domain size interval. This interesting observation can be interpreted as a result of a uniform distribution of pinning centers of random direction. The relatively larger variance in small domains leads to a stronger bias but is averaged to almost zero in large domains.

REFERENCES

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